# POLLUTION PREVENTION EQUIPMENT PROGRAM

# 1997 PREPRODUCTION INITIATIVE

# FINAL REPORT

## ENGINE GAS PATH EFFLUENT PRETREATMENT SYSTEM (AIRCRAFT)

### NAS JACKSONVILLE

**1 March 2000**

**Prepared by:**
**Naval Air Warfare Center**
**Lakehurst, NJ**

# PREPRODUCTION INITIATIVE-NELP
# ENGINE GAS PATH EFFLUENT PRETREATMENT SYSTEM
# FINAL REPORT

## NAS JACKSONSVILLE, FL

## 1.0 INTRODUCTION

The U.S. Navy has adopted a proactive and progressive position toward protecting the environment and complying with environmental laws and regulations. Rather than merely controlling and treating hazardous waste by end-of-the-pipe measures, the Navy has instituted a program for pollution prevention (P2) to reduce or eliminate the volume and toxicity of waste, air emissions, and effluent discharges.

P2 allows the Navy to meet or exceed current and future regulatory mandates and to achieve Navy-established goals for reducing hazardous waste generation and toxic chemical usage. P2 measures are implemented in a manner that maintains or enhances Navy readiness. Additional benefits include increased operational efficiency, reduced costs and increased worker safety.

The Navy has truly set the standard for the procurement and implementation of P2 equipment. The Chief of Naval Operations (CNO), Environmental Protection, Safety, and Occupational Health Division (N45), established the Pollution Prevention Equipment Program (PPEP), through which both the Naval Air Warfare Center Lakehurst (NAWCADLKE) and the Naval Facilities Engineering Service Center (NFESC) serve as procurement agents under the direction of N45. P2 equipment is specified and procured under two complementary initiatives—the Preproduction Initiative (*i.e.*, technology demonstration) and the Competitive Procurement Initiative. The Preproduction Initiative directly supports both the Navy Environmental Leadership Program (NELP) for P2 shore applications and the P2 Afloat Program, which prototypes and procures P2 equipment specific to the needs of ships.

This report provides an analysis of the procurement, installation, and operation of P2 equipment under the Preproduction Initiative. Technology demonstrations and evaluations are primarily performed under NELP at two designated NELP sites—Naval Air Station (NAS) North Island and Naval Station (NS) Mayport. Additional sites such as NAS Jacksonville have been added as required to meet specific mission goals. The program involves defining requirements, performing site surveys, procuring and installing equipment, training operators, and collecting data during an operational test period. The equipment is assessed for environmental benefits, labor and cost savings, and ability to interface with site operations.

## 2.0 BACKGROUND

### 2.1 U.S. Navy Aircraft Engine Gas Pathway Cleaning

Standard Navy maintenance practices require that aircraft engine gas pathways be flushed regularly to ensure optimal engine performance. This is accomplished by using the corrosion control cart—a piece of support equipment that dispenses detergent and fresh water into the aircraft engine gas pathway. Previously, the wash water from this practice was allowed to drain onto the tarmac uncontained. Although the detergent is not hazardous, it was recently determined that this wash water may contain harmful contaminants. The characteristics and quantity of contaminants in the wash water depend primarily on the type of aircraft engine. The Navy has conducted studies to identify which engines generate or have the potential to generate hazardous wastewater, as well as measures to eliminate the source of these contaminants. The Navy has also mandated that all engine wash water be contained and disposed of appropriately. From a Navy-wide perspective, it has been difficult to assess the scope of the problem due to varying operating procedures within the aircraft community and, in turn, different sample results. Other factors affecting sample characteristics include climate and environmental conditions, salt encrustation, engine type, age, and flight hours.

One engine in particular, the T56, has been proven to yield cadmium-contaminated wash water. The T56 engine is installed in the P-3, C-130, and E-2/C-2 aircraft. The compressor blades within this engine are nickel-cadmium coated; since this coating is a sacrificial anode to control corrosion, the coating leaches into the wash water. The Navy's long-term plan to prevent this source of pollution involves replacing all cadmium-coated compressor blades in existing T56 engines with aluminum blades over a ten-year attrition schedule.

### 2.2 NAS Jacksonville Aircraft Engine Gas Pathway Cleaning

NAS Jacksonville is responsible for maintaining a variety of aircraft, including several P-3 squadrons. Maintenance practices require NAS Jacksonville to wash aircraft engines on a routine basis. Prior to the Navy's mandate to capture and appropriately dispose of engine wash water, an investigation indicated that T56 engine wash water from P-3 aircraft on base contained quantities of heavy metals that exceeded the hazardous waste disposal limits defined by 40CFR 261.4. NAS Jacksonville began taking steps to rectify this situation; however, in 1996 the Florida Department of Environmental Protection (DEP) cited NAS Jacksonville for a violation of state hazardous waste statutes. NAS Jacksonville's previous practice of allowing wash water to drain onto the tarmac was considered an illegal discharge. This citation carried serious fiscal implications in addition to potential civil and criminal liabilities for improper disposal of a hazardous waste. In response to this citation and the Navy's new 100-percent capture mandate, it was deemed necessary to capture, contain and properly treat or dispose of the effluent. Initially, this entailed disposal of the aircraft wash water as a hazardous waste. Once the site requirements were defined and the wastestream was characterized and quantified, it was determined that the wastewater could be rendered nonhazardous via a pretreatment system and discharged to the Navy Owned Treatment Works (NOTW) for final treatment rather than off-site disposal.

As part of an agreement between the Florida DEP and NAS Jacksonville, a consent order mandated that NAS Jacksonville test two different pretreatment technologies for the purpose of rendering the waste acceptable for treatment at the NOTW. Participation in this study, termed a Supplemental Environmental Project (SEP) under the consent order, partially relieved environmental fines for NAS Jacksonville.

The Pollution Prevention Equipment Program (PPEP) undertook management of this pretreatment technology demonstration, the results of which will satisfy the NAS Jacksonville consent order, as well as establish the Navy’s short-term strategy for handling T56 engine wash water waste. The number of available technologies capable of treating the T56 engine wash water was narrowed by NAS Jacksonville requirements. The pretreatment system to be selected was required to efficiently treat small batch volumes of wastewater containing free oil, chemically and mechanically emulsified oils, grease, solvents, lubricants, and heavy metals to meet the stringent effluent requirements of the NOTW. The treatment system was also required to efficiently interface with the site and existing aircraft maintenance procedures.

## 2.3 Pretreatment System Selection

Several pretreatment systems were considered. Two technologies, ion adsorption and chemical precipitation, proved to be the leading systems based on heavy-metal removal efficiency, ease of use, and system cost. These systems are commercially available and used in similar, if not identical, applications. Electrocoagulation, dissolved air flotation, atmospheric evaporation, crystallization, and aqueous bi-phase extraction were also considered.

### *2.3.1 Ion Adsorption*

<u>Process</u>

Filtration removes free and mechanically emulsified oils, and suspended solids. After filtration, the wastewater flows through a media bed composed of ionic material. The adsorbent media removes heavy metals and chemically emulsified oils by functioning as an ion exchange medium. Cation and anion molecules are drawn out of the solution and adsorbed by the media bed.

<u>Advantages</u>

- Minimal operator intervention is required.
- Effectively removes/reduces the concentration of a wide range of contaminants.
- Cost-effective for batch treatment.

- System operation is independent of fluctuations of contaminant concentration in the wash water. (If contaminants are present, they will be removed; if not, the wastewater will pass through the system unchanged.)
- Stagnant water in the system for extended periods does not pose a problem.
- Outside storage is not a problem; however, protection from freezing temperatures may be required depending on the climate.

Disadvantages

- Media replacement is expensive. (However, this will be nominal due to an estimated low volume of throughput.)
- Regeneration of media is not cost-effective. Spent filters and media must be disposed of as a hazardous waste. (This will be infrequent due to the estimated low volume of throughput.)

### *2.3.2 Chemical Precipitation*

Process

Chemicals are added to the wastewater to lower pH and reduce certain constituent materials in the wastewater. An emulsion breaker is added to release chemically and mechanically emulsified oils. An oil/water separator, dissolved air flotation unit, or filtration unit is then used to remove the released oil. Chemicals are added to raise the pH for heavy metal precipitation. A flocculent is added to facilitate settling in a clarifier. Generated sludge is withdrawn, treated with a sludge thickener, and dewatered in a filter press.

Advantages

- Cost-effective for large, continuous flows.
- Effectively removes/reduces the concentration of a wide range of contaminants.
- Stagnant water in the system for extended periods does not pose a problem.
- Outside storage is not a problem; however, protection from freezing temperatures may be required depending on the climate.

Disadvantages

- Operator-intensive.
- Time consuming, as treatment requires additional time to adjust the pH, precipitate contaminants, and form floc.
- Actual concentration of wastewater contaminants may affect the amount of chemicals needed to process the wash water. The potential exists to either under- or overtreat.
- Combining the chemicals and flocculent with the wastewater generates additional sludge that requires disposal and may be hazardous.
- Requires the storage and handling of potentially toxic chemicals.

Taking into account the low volume batch flow, implementation and effluent limit requirements at NAS Jacksonville, it was recommended that ion adsorption be the first treatment technology tested at the site. This technology was chosen because it can efficiently remove contaminants in the T56 wash water down to the discharge limits set by the NOTW. The ion adsorption treatment system is neither labor- nor energy-intensive. Minimal operator intervention is required. The operator needs only to empty the drums of untreated wastewater into the influent holding tank and turn on the system. Once the treated wastewater is in the effluent holding tank, the operator takes a post-treatment sample; when laboratory testing verifies that effluent limits have been met, the effluent is discharged to the NOTW.

For a small volume application such as NAS Jacksonville's, the operating cost and difference in capital cost between an ion absorption system and other viable technologies is significant. Chemical precipitation, for instance, is labor-intensive and more expensive for small volumes of wastewater. Chemical addition is not as costly as the filters and media used in the ion adsorption system; however, as the volume of wastewater decreases, the lower material costs of the chemical precipitation system are overcome by labor costs. Therefore, savings on materials do not make up for the added expense of operator involvement in small volume batch processes.

Ion adsorption also allows for a fluctuation in the contaminant levels of the raw wastewater (i.e., influent). Differences in raw water constituent concentrations are inconsequential when ion adsorption is used to remove heavy metals and can vary considerably without change in effluent quality. With technologies such as chemical precipitation, raw water constituent concentrations must be determined for each specific batch in order to add the appropriate proportion of chemicals. Miscalculating the chemical proportions leads to over- or undertreatment of the wastewater. Overtreatment is caused by adding excessive amounts of chemicals, which increases consumable material costs. It also generates excessive amounts of sludge, which increases disposal costs. Undertreatment leads to discharge violations, excessive sampling costs, and increased labor costs from repeat treatments.

To overcome some of the disadvantages associated with conventional multistep chemical precipitation methods, a second pretreatment system was selected that combines chemical precipitation and ion adsorption technologies. The chemical precipitation/ion adsorption system chosen can accommodate fluctuations in wastewater contaminants and reduce the treatment time and operator intervention typically associated with chemical precipitation by using a proprietary blend of nonhazardous, high-uptake, natural and synthetic minerals known commercially as Aquasil. Aquasil precipitates, adsorbs, and flocculates most wastewater contaminants in one step, thereby simplifying the treatment process. This multipurpose additive precludes the need to dispense, monitor, and store hazardous pH-adjusting, precipitating, and floc-forming additives. It also eliminates the need for oil-removing equipment such as soil/water separators, dissolved air flotation, filtration, etc. The required mineral dosage is easily determined through a simple field jar test, which significantly reduces the possibility of over- or undertreatment, the need for repeat treatments, and excess sludge generation. The generated sludge usually can be disposed of as nonhazardous material because it typically passes the toxicity characteristics leaching procedure (TCLP). (Note: Lab analysis is still required to verify TCLP.)

## 3.0 EQUIPMENT DESCRIPTION

The first pretreatment system selected was the ContamAway II ion adsorption pretreatment system manufactured by WaterSmart Environmental, Inc. This system is an automated, small flow, multipurpose, medium-duty, factory-packaged aqueous wastewater treatment plant designed to remove free oils and fuels, gross settleable solids and fine suspended solids (to one-micron), chemically and mechanically emulsified oils, grease, solvents, lubricants, and heavy metals (e.g., cadmium) to near nondetectable levels.

The second pretreatment system selected was the Aquachem chemical precipitation/ion adsorption pretreatment system manufactured by Aquachem, Inc. This system is a skid-mounted, automated, factory-packaged, high-uptake, aqueous wastewater treatment batch reactor designed to remove oil and grease, suspended solids, and soluble heavy metals (e.g., cadmium) from the wastestream to near nondetectable levels.

### 3.1 System Components

The WaterSmart ion adsorption system includes, but is not limited to, the following major components:

- One epoxy-coated skid with the following equipment mounted, prepiped, and prewired. The skid includes holes in the beams for anchoring
- One lot of pipe insulation and heat trace applied to piping on the skid
- One 500-gallon polyethylene influent holding tank
- One air diffuser header, installed within the *influent* holding tank, to allow "roll" mixing of tank content
- One control panel with audible and visual alarms
- One 15-gpm feed pump
- One cartridge filter capsule assembled with four one-micron filters
- Two cartridge filter capsules assembled with eight five-micron filters
- Two media capsules assembled with tri-media (granular activated carbon, OrganoSorb, FloMag G)
- One 500-gallon polyethylene effluent holding tank
- One air diffuser header, installed within the *effluent* holding tank, to allow "roll" mixing of tank content.

The Aquachem chemical precipitation/ion adsorption system includes, but is not limited to, the following major components:

- One steel, epoxy-coated skid with the following equipment mounted, prepiped and prewired. The skid includes holes in the beams for anchoring

- One integral steel work platform with vertical ladder for operation access and inspection, mounted on system skid
- One lot of pipe insulation and heat trace applied to the piping on the skid
- One NEMA 4X fiberglass control panel with audible horn alarm and flashing red beacon alarm for “Bag Filters Full - Ready to Treat - Cycle Complete”
- One 500-gallon conical bottom, polyethylene treatment/influent holding tank with polyethylene stand, fittings, and sampling ports. Includes a high-level sensor, which activates a set of dry contacts to lock out feed pumps at low level
- One Aquasil batch feeding system mounted on the skid to automatically dose the additive into the batch treatment tank for each cycle
- One 1/3-hp mixer, clamp-mounted, with stainless steel shaft and propeller, mounted on treatment tank
- One air-operated diaphragm pump mounted and piped on the skid with associated air filter, regulator, lubricator, needle valve, solenoid valve and shutoff valve
- Two bag filter assemblies within polypropylene housings, one operating and one standby, with manual valve switchover and pressure switch indication of “Bag Filter Full”
- One 500-gallon polyethylene effluent holding tank with polyethylene stand, fittings, and sampling ports
- One air diffuser header, installed within the *effluent* holding tank, to allow “roll” mixing of tank content.

## 3.2 Implementation Requirements

| | WaterSmart Ion Adsorption System | Aquachem Chemical Precipitation/Ion Adsorption System |
|---|---|---|
| Power requirement | 11/220V, single phase | 115 V, single phase, 60 Hz |
| Air requirement | None | 100 psi continuous |
| Water requirement | To prime the pump | 50 psi |
| Dimensions | 12’ high x 15’ long x 5’ wide (includes free area on skid for anion absorber if necessary) | 9’ high x 9’-6” long x 7’-8” wide |

## 3.3 Treatment Process

The WaterSmart ion adsorption treatment process at NAS Jacksonville begins when engine wash wastewater, previously captured at the flight line, is emptied from drums via a drum pump into the system’s influent wastewater collection tank (system collection tanks were sized to accommodate the largest potential batch volume). Operators should ensure that all drums are sufficiently emptied in accordance with 40 CFR 261.7, which requires that all wastes be removed using commonly employed practices (e.g., pouring, pumping, and aspirating), that no more than 1 inch of residue remains on the bottom of the container, or that no more than 3 percent by weight of the total capacity of the container remains in the container. The influent collection tank is equipped with an air distribution header that mixes the influent for sampling purposes. After samples are taken, the air distribution header is turned off. The influent tank holds the wastewater and allows free and mechanically emulsified oils to accumulate before treatment. A sump pump transfers the wastewater from the pretreatment collection tank into the unit and through a five-micron filter that removes particulates. Wastewater then flows through an oversized coalescing filter that removes free and mechanically emulsified oils and suspended solids as small as one micron. Finally, the wastewater flows through a tri-media adsorbent bed of KF200, granular activated carbon, and FloMagG. This final stage of treatment removes chemically emulsified oils and heavy metals. Treated water is then transferred to the effluent holding tank for storage while laboratory analysis of the treated water is being performed. An air distribution header within the effluent holding tank is employed to provide a well-mixed sample for laboratory testing as well as to lower pH levels. When laboratory analysis confirms that the treated water is within acceptable limits, the effluent is discharged to the NOTW.

The Aquachem chemical precipitation/ion adsorption treatment process at NAS Jacksonville begins when engine wastewater, previously captured at the flight line, is emptied from the collection drums, via a drum pump, into the system's 500-gallon conical bottom, polyethylene, batch wastewater treatment tank (system collection tanks were sized to accommodate the largest potential batch volume). Operators should ensure that all drums are sufficiently emptied in accordance with 40 CFR 261.7, which requires that all wastes be removed using commonly employed practices (e.g., pouring, pumping, and aspirating), that no more than 1 inch of residue remains on the bottom of the container, or that no more than 3 percent by weight of the total capacity of the container remains in the container. When a sufficient quantity of wastewater has been accumulated in the treatment tank, the dry contact sensors in the treatment tank activate a ready-to-treat indicator on the control panel. The operator can then manually activate the influent collection tank mixer for sampling purposes. After samples are taken, the mixer is turned off and the operator can activate the treatment cycle in automatic or manual mode from the control panel. Once the treatment cycle begins, Aquasil is dispensed from the adjustable dose, chemical-feeding system and blended with the wastewater via the mixer for an adjustable amount of time. The Aquasil chemically precipitates and adsorbs contaminants in that batch of wastewater and forms a floc, which settles to the bottom of the treatment tank. Toward the end of the mixing cycle, a grab sample is taken from the treatment tank sampling port. The water clarity and floc formation in the treated sample are observed to determine whether adequate treatment has been achieved. Additional Aquasil dosing and mixing can be performed if the water treatment is found to be inadequate. The settled floc and treated wastewater are then pumped from the treatment tank via the air diaphragm pump through the bag filter, which separates the floc (i.e., contaminants) from the wastestream. The treated water is then transferred to the effluent holding tank. The air distribution header within the effluent holding tank is used to provide a well-mixed sample for laboratory testing, as well as to lower pH levels. When laboratory analysis confirms that the treated water is within acceptable limits, the effluent is discharged to the NOTW.

## 3.4 Maintenance

The WaterSmart ion adsorption system requires only two maintenance tasks: replacement of the filter cartridges and replacement of the adsorptive media beds. Alarms activated by pressure differentials indicate when clogged filters should be replaced. The one- and five-micron filters can be ordered and replaced on-site by NAS Jacksonville. Periodic sampling determines when the adsorptive capacity of the tri-media has been reached and requires replacement. The spent tri-media can be removed and disposed of by NAS Jacksonville, but it is recommended that WaterSmart, Inc. repack the media bed. Replacing the tri-media bed requires a complex back-washing procedure, which if performed improperly could significantly reduce the adsorptive capacity of the new media. Although the manufacturer has supplied this back-washing procedure, it is recommended that the emptied media canister be shipped to WaterSmart, Inc. for tri-media replacement. NAS Jacksonville must ensure that appropriate measures are taken to transport the used bed as hazardous material. When the tri-media canister is repacked with new media, it can be returned to NAS Jacksonville for reinstallation.

The Aquachem chemical precipitation/ion adsorption system requires only one maintenance task: replacement of the bag filter cartridges. Alarms activated by pressure differentials indicate when a clogged filter needs be replaced. When the operating filter is full, the system can be manually switched over to a second backup filter, allowing for continuous treatment operations. The spent 25-micron bag filter is then easily removed from its holding canister. During the test period, NAS Jacksonville removed, sampled, and disposed of spent filters as a nonhazardous material after passing the TCLP and flashpoint analysis.

## 3.5 Benefits

Overall, both technologies accomplish the following:

- Reduce toxicity in the wastestream
- Reduce the volume of wastestream
- Comply with wastewater discharge requirements.

# 4.0 DATA ANALYSIS

Data concerning the WaterSmart ion adsorption pretreatment system were collected at NAS Jacksonville from July 1998 to January 1999.

Data concerning the Aquachem chemical precipitation/ion adsorption system were collected at NAS Jacksonville from June 1999 to December 1999.

## 4.1 Quantitative Analysis

The data collected for the WaterSmart ion adsorption system were reviewed and analyzed to produce a cost-benefit analysis. The 10-year return on investment was $145,024.50, with a payback period of 2.13 years.

The data collected for the Aquachem chemical precipitation/ion adsorption system were reviewed and analyzed to produce a cost-benefit analysis. The 10-year return on investment was $128,780, with a payback period of 2.03 years.

It should also be noted that the systems provided compliance benefits that reduced costly fines. Calculations in the cost analysis did not account for the unique expenses and funding at NAS Jacksonville; only standard capital and operating costs were considered. If these unique expenses and funding were considered, the cost-benefit analysis at NAS Jacksonville would have indicated immediate savings and a payback period of 0 years as a result of fine relief. (Refer to the cost analysis for complete data.)

## 4.2 Qualitative Analysis

### *4.2.1 Permits*

Because these technology demonstrations were in direct response to a compliance issue and were arranged after considerable involvement by the Florida DEP, the pretreatment systems operate under DEP approval. Implementation of these systems at other sites will require consultation with the local environmental agency to determine whether permits or permit modifications are required. Some potential sites may discharge their wastewater directly to surface water, while others may discharge into a sanitary sewer system/sewage treatment plant. If discharging to surface water, an NPDES permit or a modification to an existing NPDES permit most likely will be required. If the discharge goes to a sewer system, the discharger must comply with the minimum regulatory requirements mandated by the state, locality, and/or POTW/NOTW. When a discharger meets or fails to meet one of these specifically mandated criteria, a discharge permit may be required. Although these systems, as configured at NAS Jacksonville, are exempt from RCRA permitting (because the unit is a pretreatment system and is not used for final hazardous waste disposal), spent filters and adsorptive media should be considered hazardous waste unless tests conclude otherwise, and must be managed and disposed of in accordance with RCRA requirements.

### *4.2.2 Interface with Site Operations*

Initially, interface with site operations hinged on obtaining DEP concurrence with the plan to transport the wastewater from the wash site to the pretreatment site and finding a reliable method to achieve this. The NAS Jacksonville-developed P-3 capture cart had already been implemented in response to the immediate need for containment. Wash water is captured with the cart and contained within drums. (Note: Wash water is treated within 90 days of accumulation in accordance with RCRA requirements.) The drums are then used to transport the wash water to the pretreatment site. The final phase of the hazardous waste violation resolution involved approval of the selected pretreatment systems and development of a sampling/test plan.

Appropriate approvals were obtained, the method for transporting the effluent was arranged, the pretreatment systems were installed, and a methodology for sampling/testing the wastewater was implemented. Laboratory testing was required to verify the effectiveness of the system, as well as to satisfy the NOTW, which does not accept wastestreams of unquantified contaminants. It was necessary to prove that the systems were capable of pretreating the wastewater constituents to levels considered acceptable by the NOTW prior to discharge. The 500-gallon effluent tanks were specified as system components for effluent containment, while awaiting acceptable test results.

Overall, after ensuring that Florida DEP requirements were compatible with site operations, interface with site activities has been successful. Aircraft maintenance personnel need only drum, label, and transport the hazardous wastewater. Due to the operational simplicity of the selected pretreatment systems, the system operator has easily integrated wastewater treatment with other daily activities.

### *4.2.3 Installation*

Installation of the WaterSmart ion adsorption system was completed in January 1998, and the first batch of wastewater was processed in April.

Installation of the Aquachem chemical precipitation/ion adsorption system was completed in May 1999, and the first batch of wastewater was processed in May.

### *4.2.4 Training*

Training provided to operators and engineers covered issues such as system components and their function, gauges and other indicators, routine operation, maintenance procedures, and troubleshooting. The Aquachem chemical precipitation/ion adsorption system required that operators receive additional training to perform the Aquasil dosage bench test, which allows the operator to determine when the wastewater has been adequately treated.

### *4.2.5 Operation*

The first three batches of wastewater treated with the WaterSmart ion adsorption system were not immediately discharged to the NOTW because the effluent contained concentrations of heavy metal and hydrocarbons that did not meet NOTW discharge requirements. Although the effluent did not meet NOTW discharge requirement, the treated wastewater contaminant levels were sufficiently reduced to levels that rendered the effluent nonhazardous. The treated wastewater was drummed and stored as a nonhazardous material until the treatment system was operating properly.

Analysis of the laboratory test results indicated that the system was actually contaminating the wastewater in some instances. A diagnostic sampling plan was devised to troubleshoot the treatment system and isolate the malfunctioning system components. Inspections revealed rust contamination in the holding tanks, and diagnostic sampling laboratory results indicated that the media beds had prematurely reached maximum adsorptive capacity.

It was determined that the epoxy-coated steel holding tanks had not been properly sealed and were rusting. As a precaution, the holding tanks and all metal piping were replaced. Pipes and fittings were replaced with PVC, and the steel holding tanks were replaced with plastic holding tanks. While these modifications were being made, new filter cartridges and media beds were also installed. At the vendor's recommendation, dual-media beds were replaced with tri-media beds to enhance the removal efficiency of chemically emulsified oils and heavy metals. During reinstallation of the filters and media beds, it was discovered that the original one-micron filters had not been properly secured, which allowed the wastewater to bypass the one-micron filter and flow directly from the five-micron filter to the dual-media beds. The beds became clogged with fugitive contaminants, and channeling developed. This inefficient flow distribution led to a breakthrough before the full adsorptive capacity of the system had been reached. The faulty bypass of the one-micron filter and the rust accumulation in the holding tanks were the likely causes of the high heavy metal and hydrocarbon contaminant levels in the effluent. Modifications were made to restart the technology demonstration without any potentially contaminated treatment system components. All of the accumulated wastewater that was rendered nonhazardous by the previously malfunctioning system was retreated to reduce the heavy metals and hydrocarbons to limits acceptable to the NOTW.

Another modification to the system involved installing an agitation device in the influent and effluent holding tanks. Air agitation mixes the wastewater before sampling and provides a homogeneous sample that accurately represents the levels of all contaminants present. An added benefit of the air agitation system is that aeration tends to lower pH. Consistently high effluent pH levels have been accepted by the NOTW; however, aeration should lower the pH to a level that meets the stringent parameters of the NOTW.

During initial startup of the Aquachem chemical precipitation/ion adsorption system, wastewater was transferred into the system's batch treatment tank and mixed, and an influent sample was taken. It was observed that the sample was contaminated with residual Aquasil from a previous "clean" water trial run. To avoid future sample contamination during the evaluation period, wastewater was accumulated, agitated, and sampled in the WaterSmart influent holding tank before it was transferred to the Aquachem chemical precipitation/ion adsorption batch treatment tank. It was necessary to take influent samples only during the evaluation period to determine the removal efficiency. Influent samples should not be required at other sites. Only effluent sampling will be required; therefore, residual Aquasil in the treatment tank will not be a concern at other sites.

The wastewater treated with the Aquachem chemical precipitation/ion adsorption system was not immediately discharged directly to the NOTW because the effluent contained high levels of petroleum hydrocarbons. The wastewater accumulated and treated during the Aquachem chemical precipitation/ion adsorption system evaluation period contained unusually large concentrations of petroleum hydrocarbon (i.e., fuel)—an average of 230 times higher than when the WaterSmart ion adsorption system was being evaluated. The cause of the high fuel concentrations was not identified. Although Aquasil is designed to remove some fuel, it is incapable of removing the high concentrations found at NAS Jacksonville (average 5,000 mg/L) during the Aquachem chemical precipitation/ion adsorption system evaluation. In order for the Aquachem chemical precipitation/ion adsorption system to remove these fuel concentrations, the addition of a carbon canister would have been necessary. Incorporating a carbon canister was rejected due to the expense and additional time and maintenance required by the carbon canister. An alternative solution to this problem was to run the Aquachem chemical precipitation/ion adsorption effluent through the WaterSmart ion adsorption system after the heavy metals and other contaminants concentrations had been reduced by the Aquachem chemical precipitation/ion adsorption system. The WaterSmart ion adsorption system contains a media canister that is capable of removing residual fuel concentrations.

The effects of excessive amounts of oil and grease and/or microbial growth were also observed during the evaluation period. The first batch of wastewater treated in the Aquachem chemical precipitation/ion adsorption system had been accumulated over three months. During transfer of the wastewater to the batch treatment tank, it was observed that the wastewater’s consistency was very thick. The unusual thickness was attributed to excessive amounts of oil and grease and/or microbes that had grown over the three-month accumulation period. Although the overall contaminant removal efficiency was not affected, additional amounts of Aquasil and, in turn, bag filters were required to remove these excessive amounts of oil and grease and/or microbial growth. This increased the expense, time, and operator involvement required to complete the batch treatment. Also, instead of forming a floc that settled, the oil and grease and/or microbial growth caused the floc to float. When floc settles, as intended, it is pumped from the treatment tank first and the system is flushed with the treated water. Because the floc was floating, some floc remained in the treatment tank and had to be flushed out with a hose. During the last two batch treatments, the wastewater consistency was normal, the floc settled, and only the predetermined amounts of Aquasil and bag filters were required.

During the Aquasil chemical precipitation/ion adsorption pretreatment system evaluation period, another problem associated with the excessive amount of fuel in the wastewater occurred. After changing out the spent bag filters, the system operator developed a minor throat irritation. It is believed that the irritation was caused by the fuel vapors emitted from the bag filters during changeout. In the future, operators must wear a respirator during bag filter changes and Aquasil refilling operations.

### *4.2.6 Maintainability*

The WaterSmart ion adsorption pretreatment system has not required any maintenance since the filters and tri-media bed were reinstalled in June 1998. Despite relatively infrequent operation (the system is set up for batch treatment), the system requires no attention and can withstand idle periods without problem. The only expected maintenance is the changeout of filter cartridges and media beds when they reach capacity. The control panel is designed to alert the operator when filter or tri-media changeout is needed. Also, the differential pressure gauges can be monitored to allow the operator time to order new consumables if they are not in stock.

During the evaluation period, the Aquachem chemical precipitation/ion adsorption pretreatment system needed an electronic circuitboard replaced. The circuitboard controls the automated treatment cycle, including the dry chemical feeder, mixer, dry contacts, pumps, and treatment time. Before being replaced, the circuit had to be bypassed and the treatment processes had to be controlled manually. Despite relatively infrequent operation, after a freshwater rinse of the treatment tank, the system requires no attention and can withstand idle periods without problem. The only expected maintenance is the changeout of filter cartridges when they reach capacity. The filter pressure gage is designed to alert the operator when filter replacement is necessary.

### *4.2.7 Overall Performance*

Figure 1 illustrates contaminant concentrations at NAS Jacksonville and the WaterSmart ion adsorption system's removal efficiency.

NAS Jacksonville has been pleased with the performance of the WaterSmart ion adsorption system, which has operated satisfactorily since the polyethylene holding tanks and pipes, filters, and tri-media adsorptive beds were reinstalled. The system has flawlessly treated approximately 2,500 gallons of wastewater and successfully reduced *all* wastewater contaminants to discharge limits and, in most cases, to nondetectable levels. All effluent has been discharged to the NOTW. Additionally, the WaterSmart ion adsorption system has been used to "polish" approximately 1,100 gallons of effluent from the Aquachem chemical precipitation/ion adsorption system.

Figure 2 illustrates contaminant concentrations at NAS Jacksonville and the Aquachem chemical precipitation/ion adsorption system's average removal efficiency.

NAS Jacksonville has been moderately pleased with the performance of the Aquachem chemical precipitation/ion adsorption system, which has operated satisfactorily with the exception of its inability to remove large fuel concentrations. The Aquachem chemical precipitation/ion adsorption system has treated approximately 1,100 gallons of wastewater since its installation and successfully reduced all contaminants, with the exception of fuel, to discharge limits and, in most cases, to nondetectable levels. Without the addition of a carbon canister, this system is incapable of reliably removing the fluctuating fuel concentrations at NAS Jacksonville. All Aquachem chemical precipitation/ion adsorption system effluent was passed though the WaterSmart ion adsorption system to remove residual fuel. All effluent has been discharged to the NOTW.

Overall, NAS Jacksonville prefers the simplicity and reliability of the WaterSmart ion adsorption system to the somewhat operator-intensive and inconsistent Aquachem chemical precipitation/ion adsorption system.

## 5.0 LESSONS LEARNED

- Waste characterization is necessary to determine whether an individual Navy site has a compliance issue. There was no consensus of results from the various sites interviewed because there is no standard operating procedure for engine gas path washing. It is reasonable to assume that if a site maintains aircraft with T56 engines, the wastewater must either be disposed of as hazardous waste or pretreated before being discharged to a sanitary sewer, NOTW, and/or POTW.

- Agitating the wastewater is advisable when taking representative wastewater samples from the influent and effluent holding tanks. Agitation also provides a means of adjusting the pH.

- The tanks and pipes should not be constructed of steel since corrosion may occur even if the steel is epoxy-coated.

- Permitting must be considered before selection and implementation of this technology. Activities that consider using this system must check with the appropriate state regulatory agency to determine whether a permit is necessary.

- Operators should wear respirators whenever the wastewater is treated or treatment chemicals are exposed to open air.

- Wastewater should not be allowed to accumulate for prolonged periods of time. Accumulated wastewater can still be treated; however, microbial growth adds to the amount of contaminants that will need to be removed and may add to the consumables and labor required for treatment. Also, if the water to be treated is hazardous, it must be treated within 90 days in accordance with RCRA.

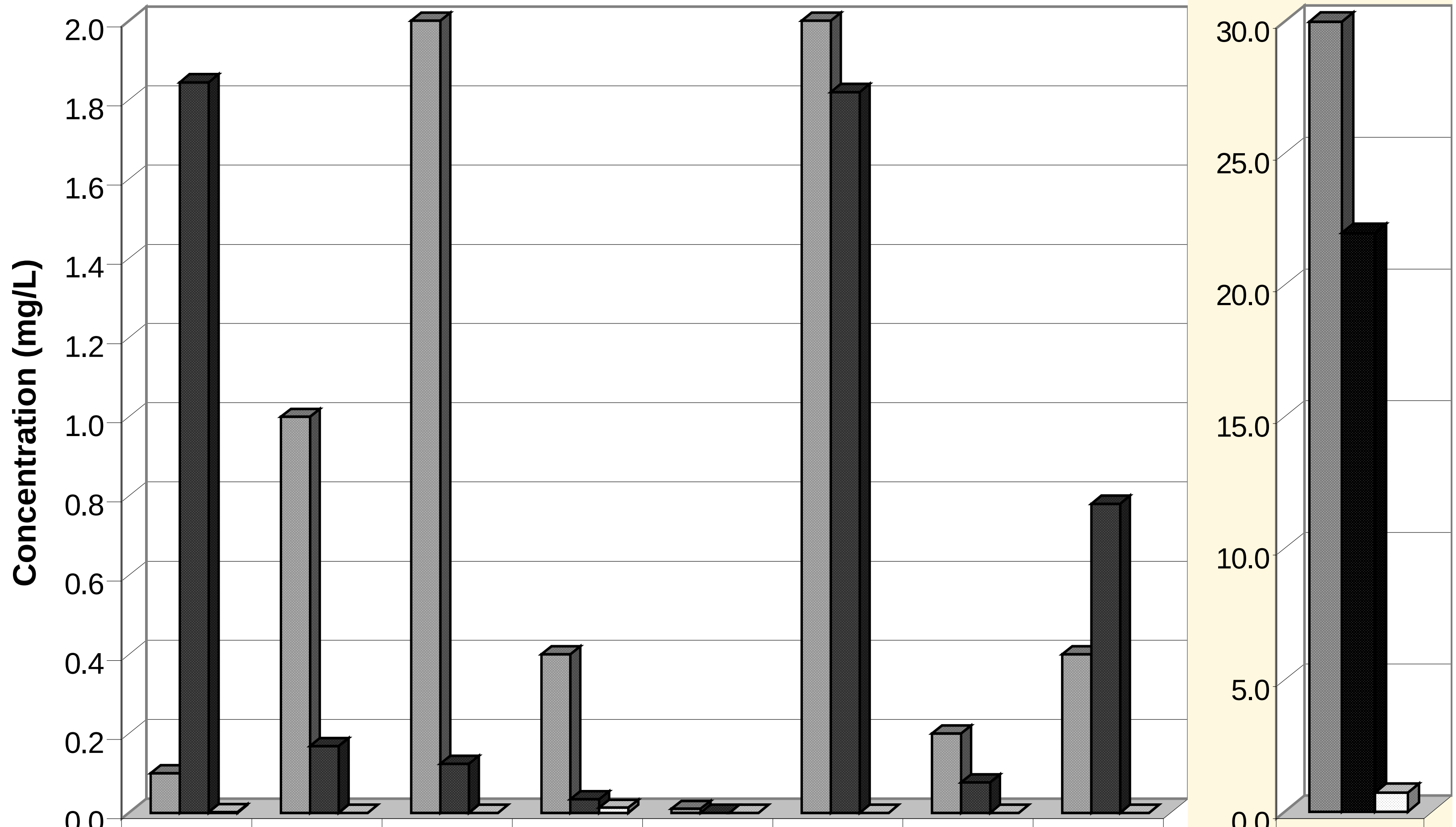
- Liquids/solids not generated during engine washing operations (i.e. fuel, oil, grease, debris, etc.) should *not* be combined with collected wash water. Unexpected contaminant fluctuations could affect the efficiency of the treatment and will increase the amount of consumables and labor associated with wash water treatment.

# 6.0 CONCLUSIONS

NAS Jacksonville is pleased with the results of these technology demonstrations in general and the performance of the WaterSmart ion adsorption pretreatment system in particular. The WaterSmart ion adsorption pretreatment system consistently brought contaminant levels to near nondetectable concentrations with little intervention from site personnel. The cost savings are apparent compared to hazardous waste disposal, and the environmental benefit is a substantial reduction in hazardous waste production. The system has provided a reliable method of handling, storing, treating, and disposing of aircraft engine wash water and ensures compliance with all local, state, federal, Navy and NOTW requirements.

The Aquachem chemical precipitation/ion adsorption system is capable of removing the wastewater contaminants at NAS Jacksonville, but only with system modifications. Without the addition of a carbon canister, the system is incapable of reliably removing the fluctuating fuel concentrations at NAS Jacksonville. In addition, the Aquachem chemical precipitation/ion adsorption treatment procedure is more operator-intensive than the WaterSmart ion adsorption system.

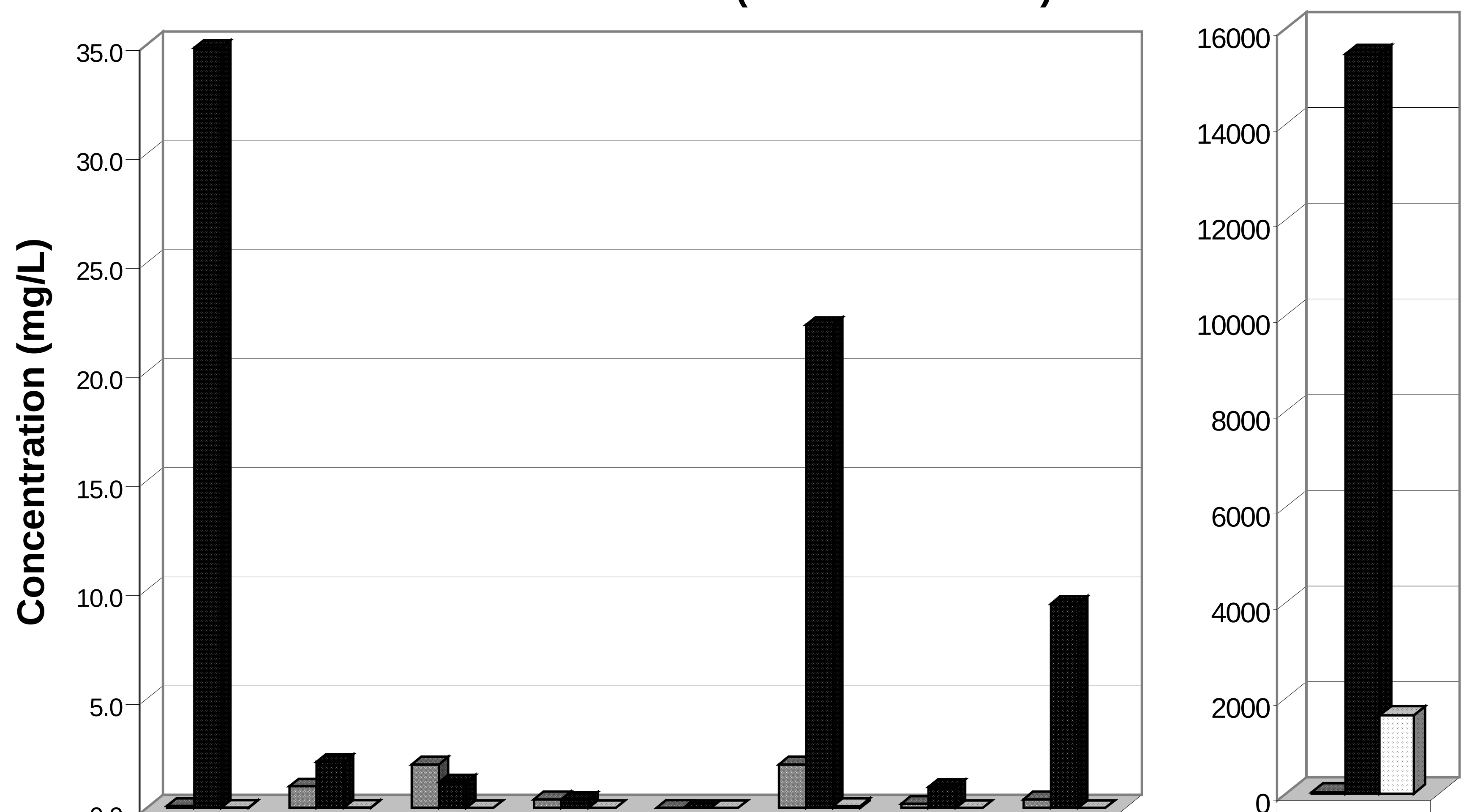
# Figure 1
# WaterSmart Ion Adsorption System
# Contaminant Limits and Levels (NAS Jacksonville)




| | Cadmium | Chromium | Copper | Lead | Mercury | Nickel | Silver | Zinc | Oil and Grease |
|---|---|---|---|---|---|---|---|---|---|
| NOTW Requirements (mg/L) | 0.1000 | 1.0000 | 2.0000 | 0.4000 | 0.0100 | 2.0000 | 0.2000 | 0.4000 | 30 |
| Influent (mg/L) | 1.8449 | 0.1685 | 0.1233 | 0.0343 | 0 | 1.8200 | 0.0768 | 0.7800 | 21.98 |
| Effluent (mg/L) | 0.0016 | 0 | 0 | 0.0125 | 0 | 0 | 0 | 0 | 0.7167 |

**Note** = Zero (0) in the data table represents a non-detectable (ND) concentration.

## (Figure 2)
## Aquachem Chemical Precipitation/Ion Adsorption System
## Contaminant Limits and Levels (NAS Jacksonville)




| | Cadmium | Chromium | Copper | Lead | Mercury | Nickel | Silver | Zinc | Oil and Grease |
|---|---|---|---|---|---|---|---|---|---|
| NOTW Requirements (mg/L) | 0.1000 | 1.0000 | 2.0000 | 0.4000 | 0.0100 | 2.0000 | 0.2000 | 0.4000 | 30 |
| Influent (mg/L) | 34.8667 | 2.1133 | 1.1800 | 0.3907 | 0.0005 | 22.1667 | 0.9603 | 9.3667 | 15463 |
| Effluent (mg/L) | 0.0130 | 0.0163 | 0 | 0 | 0 | 0.0900 | 0 | 0 | 1638 |

**Note** = Zero (0) in the data table represents a non-detectable (ND) concentration.